

CHAPTER 8

Chemical Reactions

Describing Chemical Change:

Chemical reaction:

- One or more substances change into one or more new substances

Reactants \longrightarrow Products

Describing Chemical Change:

- **Reactants:** those substances that are reacting or changing
- **Products:** those substances that are being formed from the reactants

Describing Chemical Change:

- In writing a chemical reaction, an arrow is used to separate the reactants from the products
- The \rightarrow means “yields”, or “reacts to produce”

Describing Chemical Change:

- Chemical equations: using chemical formulas to describe in writing a chemical reaction
- The arrow separates the formulas of the reactants from the formulas of the products

Types of Equations

Word equation:

- ▣ Words are used to express the reaction
- ▣ Shows just the names of the reactants and products

iron + oxygen → iron (III) oxide

Types of Equations

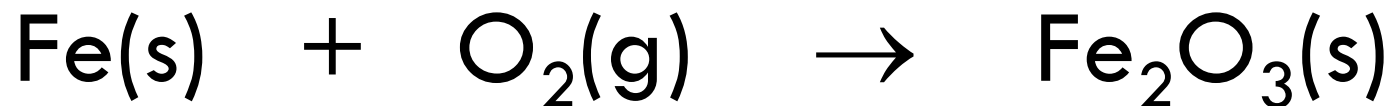
- Skeleton equation:
 - ▣ Does not indicate relative amounts
 - ▣ Shows just the formulas of the reactants and products



Chemical Equations

Symbols are used to represent the states of substances:

- solid (s), liquid (l), gas (g) and aqueous (aq)



Chemical Equations

Catalyst:

- A substance that speeds up the rate of a reaction but is not used up in the reaction
- The catalyst is written above or below the arrow

Describing Chemical Change:

- All chemical reactions must follow the law of conservation of matter
- This means that the number of atoms on each side of the equation must be equal

Balancing Chemical Equations:

- Balanced equations usually contain coefficients:
- Coefficients are numbers placed in front of the symbols for the reactants and products

Balancing Equations:

- A balanced chemical equation has the same number of atoms of each element on each side of the equation

Balancing Equations:



- Each side of the equation has the same number of carbon and oxygen atoms
- The equation is balanced

Balancing Equations:

1. First determine the correct formulas for all the reactants and products
You may include the states of the substances
2. Write the correct formulas: “skeleton equation”
3. Count the numbers of each element on each side of the equation
 - If there is a polyatomic ion that appears unchanged on both sides of the equation, treat it as a single unit

Balancing Equations:

4. Balance the elements one at a time using coefficients. Begin with the elements that appear only once on each side of the equation.
5. Check each atom or polyatomic ion to be sure the equation is balanced.
6. Make sure the coefficients are in the lowest whole number ratio

Balancing Example

Given an unbalanced equation:



$$\text{N} = 2$$

$$\text{H} = 2$$

$$\text{N} = 1$$

$$\text{H} = 3$$

Use coefficients to balance: put a “2” in front of the NH_3 and a “3” in front of H_2



Types of Chemical Reactions

Five Types of Reactions

1. Combination (or synthesis)
2. Decomposition
3. Single-Replacement
4. Double-Replacement
5. Combustion

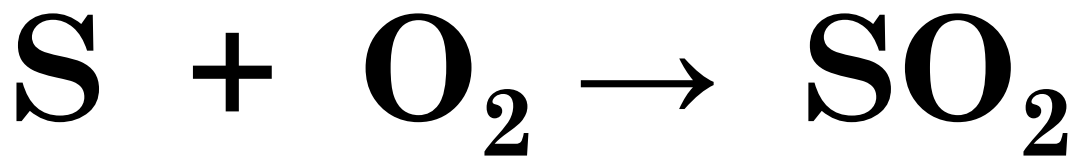
Important Note:

- Not all reactions fit into one category
- A reaction may fit equally into two or more categories of reactions

Combination Reaction:

Combination or synthesis

- Two or more reactants
- One Product (a compound)



Decomposition

One Reactant Breaks Down into
multiple Products

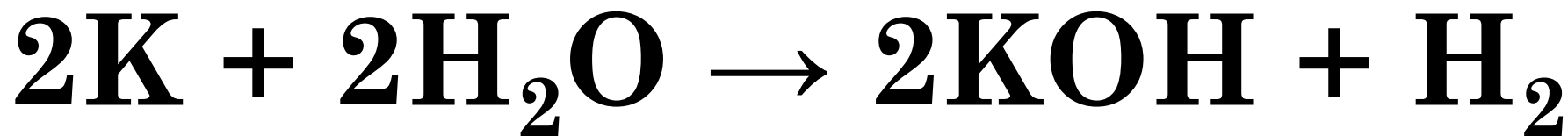
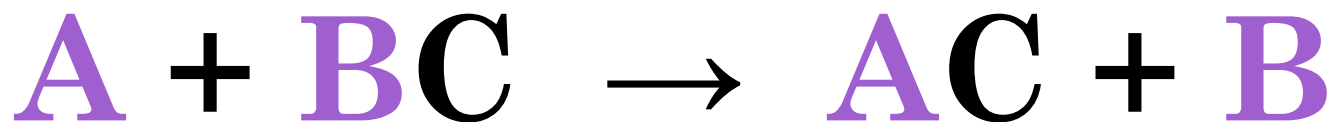


Decomposition Reaction:

- Products can be combinations of elements or compounds
- Difficult to predict
- Most require energy = heat, light or electricity

Single Replacement Reaction:

**Atoms of one element replace
atoms of a second element**



Single Replacement Reaction:

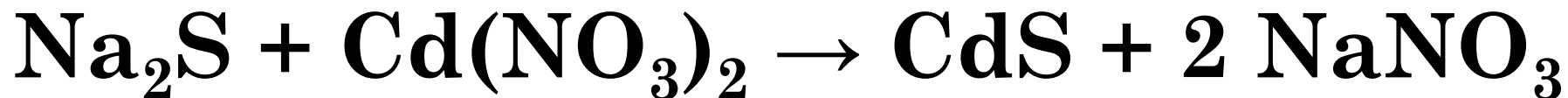
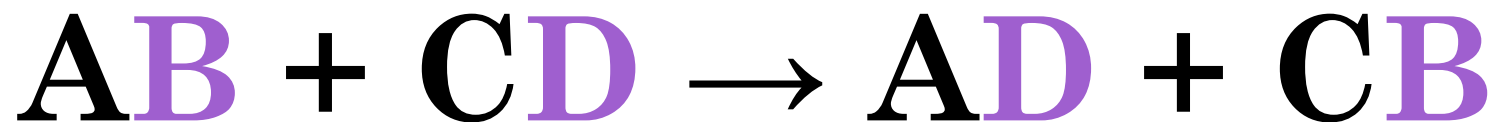
In a single replacement there are two reactants and two products.

The element that is displaced must be less active than the element that displaces it.

Activity Series	Symbol	
Lithium	Li	Always
Potassium	K	Replace
Barium	Ba	Hydrogen
Strontium	Sr	
Calcium	Ca	
Sodium	Na	
Magnesium	Mg	
Aluminum	Al	Replace
Zinc	Zn	Hydrogen
Iron	Fe	In Acids
Nickel	Ni	
Lead	Pb	
Hydrogen	H	
Copper	Cu	
Mercury	Hg	
Silver	Ag	
Gold	Au	

Double-Replacement Reaction

Two ionic compounds react by exchanging cations



Double Replacement Reaction:

Generally one of these is true:

1. One product is a precipitate.
2. One product is a gas that bubbles out of mixture
3. One product is a molecular compound such as water

Solubility Rules:

Compounds	Solubility	Exceptions
Salts of alkali metals and ammonia	Soluble	None.
Nitrate salts and chlorate salts	Soluble	None.
Sulfate salts	Soluble	Compounds of Pb, Ag, Hg, Ba, Sr, and Ca
Chloride, bromide, and iodide salts	Soluble	Compounds of Ag, Hg, and Pb
Carbonates, phosphates, chromates, sulfides, and hydroxides	Insoluble	Compounds of the alkali metals and of ammonia

Combustion:

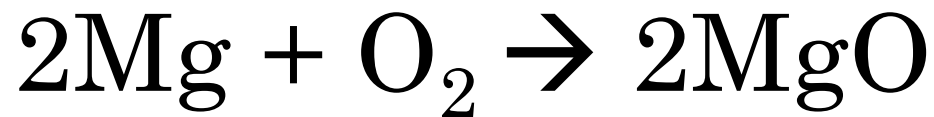
- Element or compound reacting with oxygen.
- Produces heat and light
- Product of combustion of an element is the element oxide
- Products of combustion of hydrocarbon are always carbon dioxide plus water

Combustion

An element or compound reacts with oxygen.

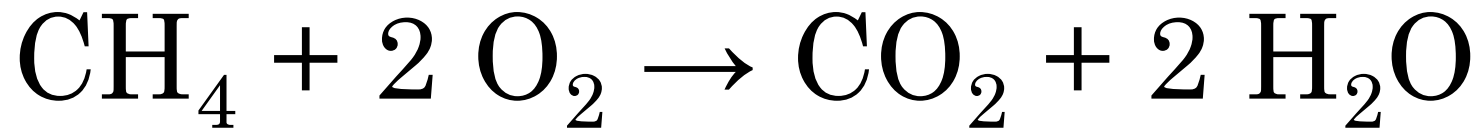
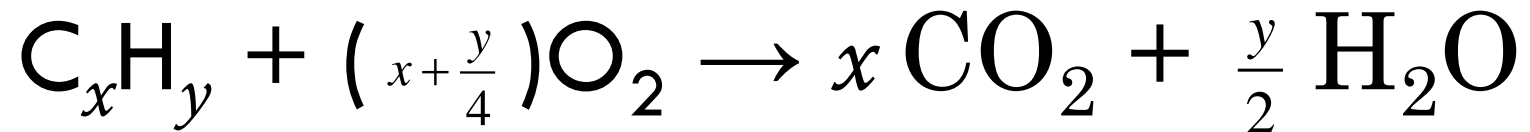
Example:

Combustion of an element



Combustion

Example: Combustion of a hydrocarbon



How to Predict Combustion



Combustion Reaction

- Products are always $\text{CO}_2 + \text{H}_2\text{O}$
- Balance equation.



- ▣ Combustion and/or Combination Reaction
 - Follow steps for combination reactions

How to Predict Reaction Products

How to Predict Reactions:

Single Replacement Reaction



Identify ions of each atom.

- Determine what can replace what
(*cation-to-cation OR anion-to-anion*).

Don't let diatomic elements throw you off!

How to Predict Reactions:

1. Is the element a metal or nonmetal?
2. If it is a metal:
Cationic Single replacement
3. If it is a nonmetal:
Anionic Single replacement
4. Consult Activity Series/Periodic table
5. Write formula for a neutral compound and an element

How to Predict Reactions:

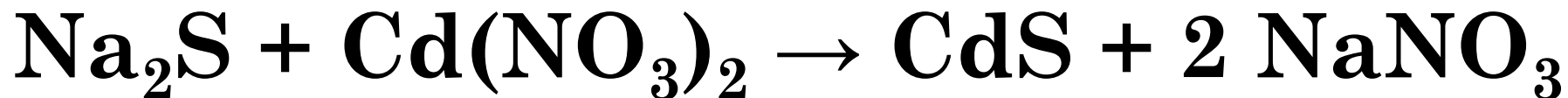
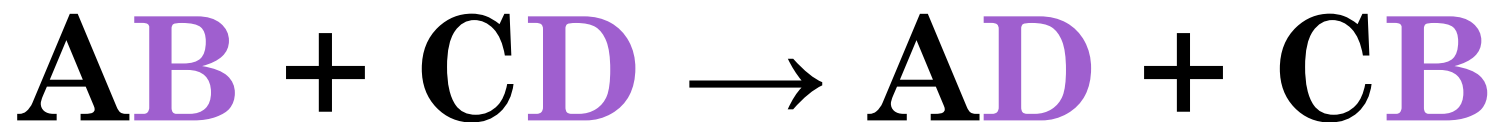
Single Replacement Reaction

- ▣ Consult Activity Series Chart! (*only elements higher on the chart can replace an atom in a compound!*)
- ▣ Make new neutral compound and element.
- ▣ Balance equation!

Activity Series	Symbol	
Lithium	Li	Always
Potassium	K	Replace
Calcium	Ca	Hydrogen
Sodium	Na	
Magnesium	Mg	
Aluminum	Al	Replace
Zinc	Zn	Hydrogen
Iron	Fe	In Acids
Lead	Pb	
Hydrogen	H	
Copper	Cu	
Mercury	Hg	
Silver	Ag	

Double-Replacement Reaction

Two ionic compounds react by exchanging cations



Double Replacement Reaction:

Generally one of these is true:

1. One product is a precipitate.
2. One product is a gas that bubbles out of mixture
3. One product is a molecular compound such as water

How to Predict Reactions:

AB + CD → (2 aqueous compounds)

Double Replacement Reaction

- Identify ions of each atom.
- Switch the cations by bonding the outside ions together and the inside ions together.
- Write neutral formulas, check solubility rules, indicate a precipitate “↓”
- Balance the equation

Solubility Rules:

Compounds	Solubility	Exceptions
Salts of alkali metals and ammonia	Soluble	None.
Nitrate salts and chlorate salts	Soluble	None.
Sulfate salts	Soluble	Compounds of Pb, Ag, Hg, Ba, Sr, and Ca
Chloride, bromide, and iodide salts	Soluble	Compounds of Ag, Hg, and Pb
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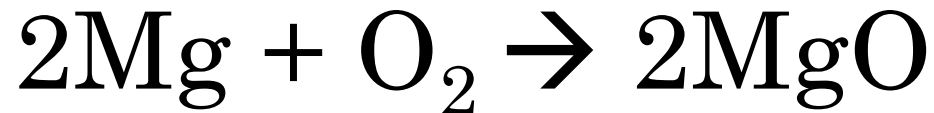
Combustion:

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Combustion

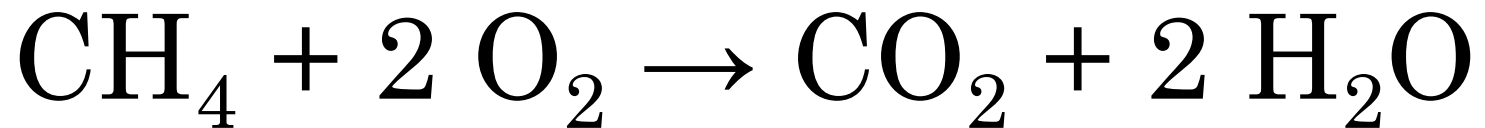
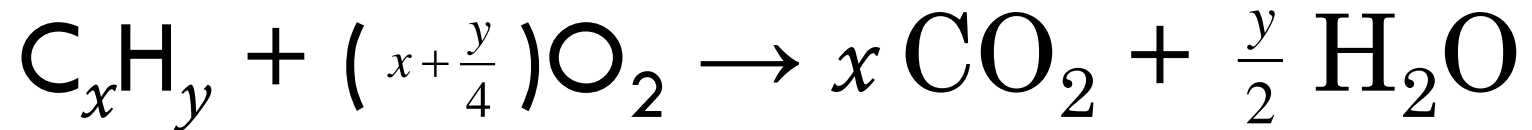
Example:

Combustion of an element



Combustion

Example: Combustion of a hydrocarbon



How to Predict Combustion



Combustion Reaction

- Products are always $\text{CO}_2 + \text{H}_2\text{O}$
- Balance equation.

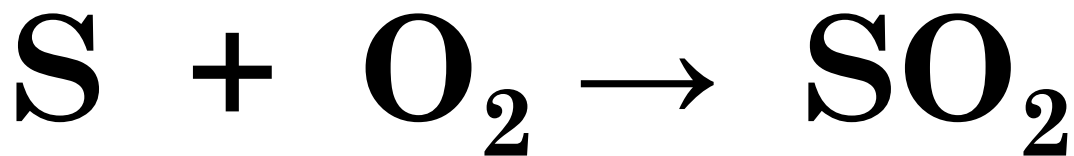


- ▣ Combustion and/or Combination Reaction
 - Follow steps for combination reactions

Combination Reaction:

Combination or synthesis

- Two or more reactants
- One Product (a compound)



How to Predict Equations

A + B → (2 elements added together)

Combination Reaction

1. Determine charges of each atom (review ion sheet)
 2. Form a neutrally charged product
 3. Balance equation
 4. Be mindful of special reactions
- *Don't let diatomic elements throw you off!***

Decomposition

One Reactant Breaks Down into
multiple Products



How to Predict Decomposition:

Decomposition Reactions

Usually under the presence of heat (Δ) or electrolysis!

- 1.** Break a binary compound into elements.
- 2.** Be mindful of diatomic elements.
- 3.** Balance equation.

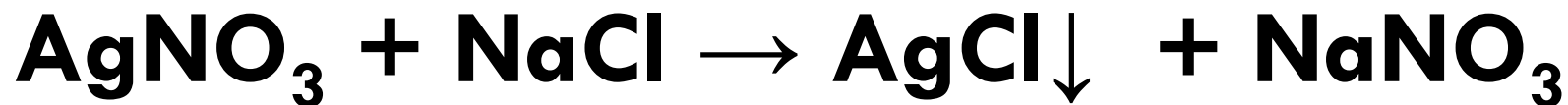
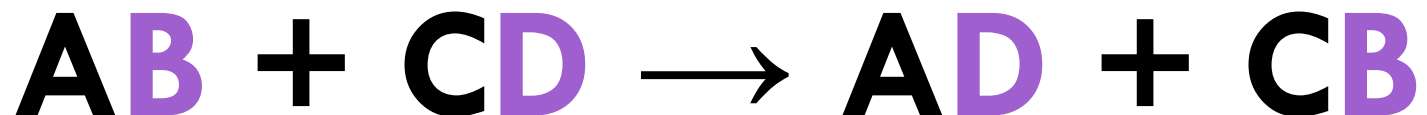
REACTIONS IN AQUEOUS SOLUTION

Aqueous Solutions

- Many important reactions take place in water
- Ionic compounds dissociate in aqueous solutions
- These solutions contain free cations and anions

Double Replacement

Two ionic compounds react by exchanging cations



Double Replacement:

Generally one of these is true:

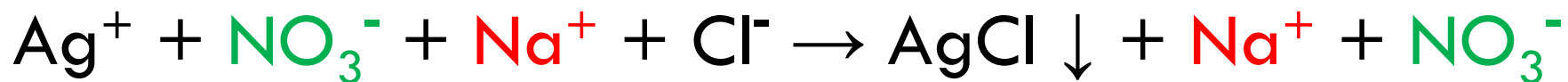
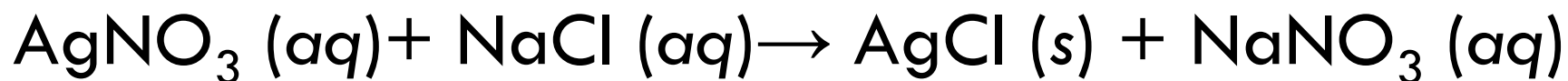
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Complete Ionic Equation

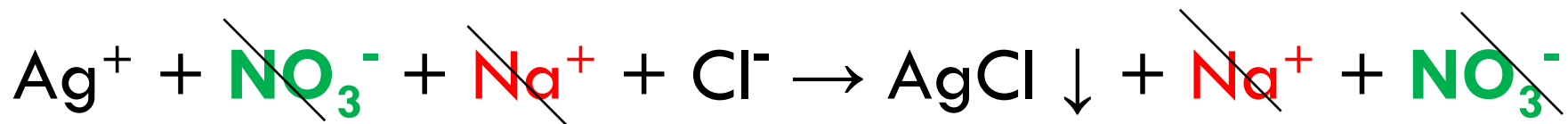
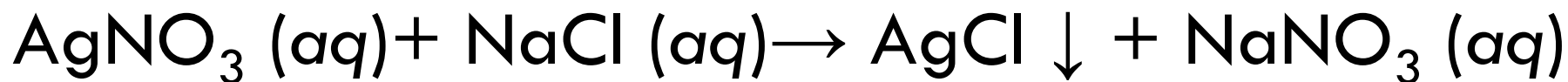
An equation that shows dissolved ionic compounds as their free ions



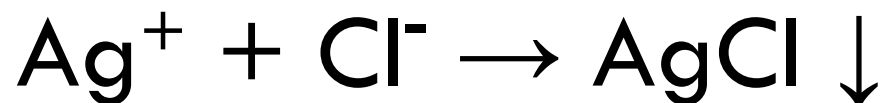
Complete Ionic Equation

- The equation can be simplified by eliminating ions that do not participate in the reaction.
- Ions that appear on both sides of the equation can be cancelled out
- These ions that are not directly involved in a reaction are called **spectator ions**

Complete Ionic Equation



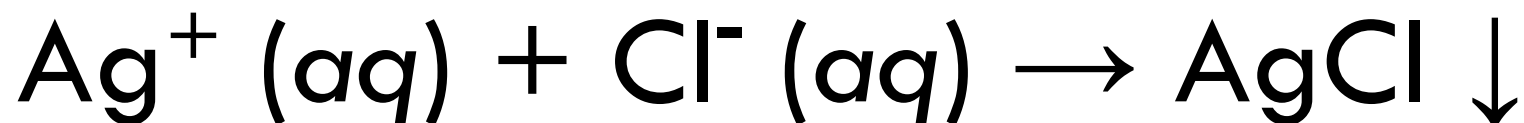
You can cross out the ions that have not changed



The resulting equation is the “Net Ionic Equation”

Net Ionic Equation

The equation that indicates only those particles that actually take part in a reaction is the net ionic equation





So

to summarize.....

Double Replacement:

If one of the products is a precipitate

1. Write the complete ionic Equation.
2. Cross out any ions that are the same on both sides of the reaction
3. Write a net ionic equation for the formation of the product.